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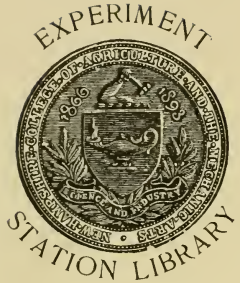

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Cucumber Leaf infested with White-fly.

THE WHITE-FLY OF GREENHOUSES

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THE WHITE-FLY OF GREENHOUSES

BY CLARENCE M. WEED AND ALBERT F. CONRADI

During recent years greenhouse crops in this and other states have been very commonly attacked by a tiny insect which has received the common name of white-fly. It is a member of a small and generally little-known family, whose technical name is Aleurodes. It accomplishes its injury by sucking the sap of its food-plants, often appearing upon the leaves in enormous numbers. A great variety of greenhouse crops suffer from its depredations, although in New Hampshire cucumbers and tomatoes growing under glass have been damaged the most.

The white-flies as a family are tropical insects. In warm climates many species are abundant out of doors, but in cold regions only a few sorts appear to be able to survive from season to season, except in the shelter of the heated greenhouse.

LIFE HISTORY

The egg of the white-fly common in our greenhouses is a minute oblong object slightly pointed at one end. The rounded end is attached to the under surface of the leaf so that the egg hangs perpendicularly downward when the leaf is horizontal. Its length is less than 1-4 mm. or about 1-100 inch. When first laid the eggs are slightly greenish yellow, but they soon become darker. Just before hatching the color is a dull glossy brown.

In a little less than two weeks (13 days according to our observations) the eggs hatch into little nymphs, which move about over the surface of the leaf for a few hours, perhaps a day; then they insert their tiny beaks into the succulent tissues of the leaf and settle down, taking on the appearance of a minute scale.

The little scale remains in position two weeks or longer; then it is a tiny flattened object, with oval outline, of a slightly greenish-yellow color, in size about 1 mm. by 1-2 mm. Under a

hand lens one can see that it is scantily clothed with minute bristles, having a denser fringe along the margins of the body.

Finally a T-shaped rupture appears in the back skin of the insect, and the adult white-fly emerges to continue the propagation of the race.

INJURIES TO THE PLANT

The mouth parts of both the nymphs and adults of the white-fly are formed for sucking, and the insects are injurious in both these stages. They insert their tiny beaks into the succulent tissues of the under surface of the leaf; the latter soon shrivels, dies, and later falls to the ground. As the adults prefer to oviposit upon the younger shoots the lower leaves of infested plants die first.

Observations and experiments carried on during the past season showed that much the most harm was caused by the work of the nymphs. Adults kept in breeding cages with plants lived a longer time than those without food, yet in no case did the plants die where adults alone were present.

Some time after the leaves are infested the under surface is covered with a sticky substance excreted by the insects. This not only tends to close the pores of the leaf, but it supports a black fungus which soon covers the entire under surface of the leaf, making it appear as though it were covered with soot. In a badly infested greenhouse the upper surface shows this fungus, but less so than the under surface.

HIBERNATION AND BROODS

We have no evidence in our New Hampshire studies that the white-flies can pass the winter out of doors. On those plants that were infested in the open last summer and since brought into the greenhouse, none of its life-history stages can be found. The treatment given those in the greenhouses subdued their numbers and at the approach of cold weather the few that remained were less active. Some adults linger among the leaves of young beets in the greenhouse during the colder weather, occasionally appearing on young tomato plants. Adults captured on January 14 and put in vials containing no food died in three days, others kept in bell jars with plants survived. No nymphs could be found at this time, and it is probable that

those few found in the house at this time of the year are adults that escaped the summer treatment.

The time required for this insect to complete all its life history stages is not more than five weeks, allowing one week's time for oviposition. It follows that an indefinite number of broods are possible, and if left unchecked their numbers may easily become most seriously destructive.

Although this species of white-fly is a serious pest on tomatoes and cucumbers it is not confined to these plants, nor is it confined to forcing houses alone. On July 18, an immense swarm was discovered in the gardens out of doors. A careful investigation was made to discover nymphs on as many plants as possible. They were found on a stray potato plant and strawberry leaves. On July 26, some were found on currant leaves, also on the leaves of a species of Erigeron. On July 29, some were found on goldenrod, and a little later a nymph was found on a chrysanthemum leaf. Of course, these were very few and in all cases on the under surface of the leaf. Unfortunately it has not been determined whether or not these nymphs complete their life history successfully.

Mr. W. E. Britton of the Connecticut station gives a list of 58 plants upon which he found the nymphs. It follows that this pest has a wide range of adaptation in food plants. In our studies we have no evidence of its establishing itself in the open in a serious way.

REMEDIAL MEASURES

Kerowater Sprays. Our experiments during the summer of 1901 showed that the adult white-flies are very easily killed by spraying with a mechanical mixture of kerosene and water, with 5 per cent. of kerosene. We used for this purpose a knapsack kerowater sprayer. When the plant on which they are resting is disturbed these adults fly into the air, making a miniature cloud. If those thus in the air are hit by the kerowater spray they drop down and die. In spraying it is desirable to begin at the top of the plants and work down.

We used this method to advantage out of doors, the adults being very easily destroyed even on badly infested plants.

The extent to which the kerowater spray can be employed to destroy the nymphs will depend largely on the plant attacked. Some greenhouse plants are very easily injured by kerosene.

Our experiments showed that the nymphs are readily killed by the kerosene spray. Doubtless kerosene emulsion could be used to equal advantage.

Hydrocyanic Acid Gas. This was the most successful, as well as the most satisfactory, remedy we tried. Statements had been made that this gas could not be used to advantage without injury to the greenhouse crops. To determine the truth of this a considerable number of tests were made, the results showing that the adult white-flies are very easily killed by an exposure too short to injure the plants. The more important of these experiments are recorded below:

On July 15, 1902, a vacant section of the greenhouse containing 2,833 cubic feet of space was stocked with tomato and squash plants and a swarm of white-flies. The gas treatment was given at 10 a. m., the day being clear and hot. Twelve ounces of strong sulphuric acid and 12 ounces of potassium cyanide were added to one gallon of water in an earthenware jar. The house was kept closed for 15 minutes, at the end of which period the adult white-flies were dead. The plants were uninjured, except a few leaves of a lily that had been growing under a greenhouse bench. In later experiments it was found that the white-flies began to fall off the plants within two minutes after the gas was formed.

Later, during the same day, the main section of the house was treated. This section was filled with fruiting tomatoes and cucumbers on which the white-flies were exceedingly abundant and destructive. At 4:30 p. m. the gas was made by adding 6 ounces of potassium cyanide to 1 pound of water to which 1 pound of strong sulphuric acid had been added. Nine minutes later the house was opened, when the earth and floors were seen to be covered by myriads of the tiny flies that had succumbed to the deadly gas. Apparently all the adult flies were killed. No plants were injured.

On July 28 and August 12 this treatment was repeated with equally successful results.

It seems evident from these experiments that the white-fly can be controlled in greenhouses by this gas treatment. The frequency of treatment and the number of treatments required to subdue the pests in a badly infested house will need to be determined by further observations.

HOW TO FUMIGATE

Before fumigating it is necessary to know the amount of space contained in the house; this will enable the operator to mix his chemicals properly. Hydrocyanic acid gas if used too strong, or if left in the house too long, will seriously injure the plants. It is therefore very important that the directions for treatment be followed carefully.

The best proportion of cyanide, sulphuric acid, and water seems to be

1 ounce cyanide of potassium,
2 ounces commercial sulphuric acid,
4 ounces water.

The water should be poured into the receiving vessel first; then the acid should be added; then the cyanide as directed more fully below. *Pour the acid into the water; never pour the water into the acid.*

In our experiments we used 1 ounce of cyanide to 400 cubic feet of space, and left the house closed but *nine* minutes. *Do not expose the plants to the gas longer than this.*

HOW TO ESTIMATE THE CUBIC SPACE IN A HOUSE

If the house is the shape of a square or a rectangle the cubic contents are found by multiplying the height, length, and width. If the house has a triangular roof with two sides equal, first find the cubic contents of the space enclosed by the walls as directed above; then find the area of the space enclosed by the roof by multiplying the width of the house by the length of the house and this result by the perpendicular distance from the top of the walls to the gable; divide this entire product by 3, and add the result to that of the space enclosed by the walls. If, however, the house is irregularly shaped the problem becomes more difficult. The cubic contents may be obtained in two ways:

a. Divide the house into rectangles, squares, and right angled triangles. The cubic contents of rectangles and squares are obtained by multiplying together the three dimensions; if a right angled triangle by multiplying the two shorter sides together and divide by 2.

b. The following method, originated by Dr. B. T. Galloway, is quoted from Prof. W. G. Johnson's "Fumigation Methods":

Procure from a stationer a sheet of cross section paper con-

taining squares of 1-4 and 1-16 inches. Let the 1-4 inch squares represent square feet. Draw on this sheet a cross section of your house, on the scale of 1-4 inch to the foot. Count the enclosed squares, reduce them to feet, and multiply by the length of the house. In this manner the exact cubic contents of any house may be easily found no matter how irregular its dimensions.

HOW TO MAKE THE GAS

The amount of cyanide used in these experiments was at the rate of 1 ounce of cyanide of potassium to 400 cubic feet of greenhouse space.

Use an earthen pot; do not use metal; this vessel should be large enough so that the liquid does not run over on to the greenhouse floor. In our experiments an earthenware gallon jar was used, and this was not any too large.

Pour the water into the vessel, add the acid; then weigh the cyanide, put it in a paper bag. Close the ventilators, and firmly fasten every door of the house except the one used by the operator. This caution should not be neglected, as the writers have repeatedly witnessed where a person unawares approached and entered the greenhouse when filled with tobacco fumes. Were this to happen when the house is filled with the hydrocyanic acid gas treatment, the result would be serious, if not fatal. When all is ready, approach the pot with the bag containing the cyanide; fill the lungs with air, hold your breath, drop in the cyanide, bag and all, and leave the house at once, lock the last door and notice the time. After the number of minutes required to kill the adult white-flies are passed open the doors and give the gas plenty of time to escape before you enter.

Hydrocyanic acid gas is very poisonous, and *the house should not be entered during treatment.*

These experiments related to tomatoes and cucumbers under glass. We do not know what effect the gas might have on other plants and advise preliminary trials before it is used.

Greenhouses used for growing vegetables can often be given a stronger treatment at times when a crop is matured and the house is empty. At such times the gas may be generated in a much larger quantity and left over night. It will thus be pretty sure to kill all insects present.

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